CAN VERTICAL PROFILES OF TROPOSPHERIC METHANE ON TITAN BE DERIVED FROM RADIO-OCCULTATION SOUNDINGS?

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The intensity of the received signal at Earth in the radio occultations of Titan is attenuated both by refractive defocusing and pressure-induced absorption from N_2-N_2 and CH_4-N_2 pairs. Because the absorption strength is different for the two sets of pairs, matching the retrieved absorptivity profile can in principle yield the vertical variation in gaseous methane in the troposphere. There are two factors that make this difficult. The first is the propagation of noise in the phase and amplitude of the received signal in the absorption retrieval. The phase data is first inverted to retrieve vertical profiles of refractivity, from which the refractive defocusing is calculated. This is then subtracted from the observed intensity attenuation of the received signal to generate a profile of atmospheric absorption. The second problem is the uncertainty in the pressure-induced absorption coefficients. Laboratory data at radio wavelengths is only available near room temperature (see, *e.g.*, [1] for N_2-N_2), and the extrapolation to the low temperatures in Titan's troposphere is not well established. Ab initio calculations by Borysow *et al.* [2, 3] provide absorption coefficients at low temperatures and long wavelengths, but their accuracy has come into question. We present examples from Cassini radio occultations of Titan to illustrate the difficulties. For methane mole fractions in the lower troposphere comparable to that inferred from the Huygens probe (~0.05), it will be difficult to separate the contributions of N_2-N_2 collisions from those of N_2-CH_4 collisions to the retrieved absorption. However, higher concentrations of CH_4 and/or a higher signal-to-noise ratio from a future uplink experiment could result in a successful separation of the two components. However, key to this are highly accurate estimates of the absorption from a combination of laboratory measurements at low temperatures and long wavelengths, and possibly improved theoretical calculations.

References

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